Electronic Version
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Claims

[c1] 1. A soft-start charge pump circuit,comprising:
a charge pump, driven by at least one clock signal, for converting a supply voltage source to a pumping voltage, the pumping voltage being a function of an amplitude of the at least one clock signal such that an absolute value of the pumping voltage is larger when the amplitude of the at least one clock signal is larger, wherein:
the amplitude of the at least one clock signal is so modulated as to gradually change from an activation value during an amplitude modulation period, the amplitude modulation period lasting longer than a period of the at least one clock signal by one or more metric orders, the charge pump being activated by the at least one clock signal with the amplitude of the activation value such that the absolute value of the pumping voltage thus generated is relatively small, the charge pump after the activation being controlled in such a way that the absolute value of the pumping voltage gradually changes along with the modulation of the amplitude of the at least one clock signal, thereby suppressing a rising rate of the absolute value of the pumping voltage.

[c2] 2. The soft-start charge pump circuit according to claim 1, wherein:
the amplitude of the at least one clock signal reaches a stable value after the amplitude modulation period.

[c3] 3. The soft-start charge pump circuit according to claim 2, wherein:
the stable value is equal to the supply voltage source.

[c4] 4. The soft-start charge pump circuit according to claim 1, wherein:
the amplitude of the at least one clock signal is determined by a gradually increasing potential difference across a capacitor when the capacitor is charged.

[c5] 5. The soft-start charge pump circuit according to claim 1, wherein:
the amplitude modulation period has a metric order of millisecond.

[c6] 6. The soft-start charge pump circuit according to claim 1, wherein:
the pumping voltage is applied to control a power switch.

[c7] 7.A soft-start charge pump circuit, comprising:
a clock amplitude modulator for generating at least one amplitude modulating clock signal whose amplitude

gradually changes from an activation value during an amplitude modulation period, the amplitude modulation period lasting longer than a period of the at least one amplitude modulating clock signal by one or more metric orders; and

a charge pump, driven by the at least one amplitude modulating clock signal, for converting a supply voltage source to a pumping voltage, wherein:

the charge pump is activated by the at least one amplitude modulating clock signal with the amplitude of the activation value such that an absolute value of the pumping voltage thus generated is relatively small, the charge pump after the activation being controlled in such a way that the absolute value of the pumping voltage gradually changes along with the modulation of the amplitude of the at least one amplitude modulating clock signal.

[c8] 8.Thesoft-start charge pump circuit according to claim 7, further comprising:

a clock generator for generating at least one constant amplitude clock signal such that the clock amplitude modulator generates the at least one amplitude modulating clock signal in response to the at least one constant amplitude clock signal.

[c9] 9.Thesoft-start charge pump circuit according to claim 7,further comprising:
an oscillator for generating an oscillation signal to the clock generator for determining a frequency of the at least one constant amplitude clock signal.

[c10] 10.Thesoft-start charge pump circuit according to claim 7, wherein:
the clock amplitude modulator determines the amplitude of the at least one amplitude modulating clock signal by using a gradually increasing potential difference across a capacitor when the capacitor is charged.

[c11] 11.Thesoft-start charge pump circuit according to claim 7, wherein:
the clock amplitude modulator includes:
a soft-start controller for generating a soft-start control signal; and
a level shifter for modulating the amplitude of the at least one amplitude modulating clock signal in response to the soft-start control signal.

[c12] 12.Thesoft-start charge pump circuit according to claim 11, wherein:
the soft-start control signal is a voltage signal with a gradually changing level.

[c13] 13.Thesoft-start charge pump circuit according to claim 12, wherein:
the amplitude of the at least one amplitude modulating clock signal is determined by the gradually changing level of the soft-start control signal.

[c14] 14.Thesoft-start charge pump circuit according to claim 11, wherein:
the soft-start controller includes:
a switch capacitor equivalent resistor having a first terminal and a second terminal, the first terminal being connected to the supply voltage source; and
a charging capacitor connected between the second terminal and a ground potential such that the soft-start control signal is asserted at the second terminal.

[c15] 15.Thesoft-start charge pump circuit according to claim 11, wherein:
the level shifter includes:
at least one clock channel for respectively generating the at least one amplitude modulating clock signal, each of the at least one clock channel having an output stage inverter whose power supply terminal is coupled to receive the soft-start control signal, thereby respectively controlling the amplitude of the at least one amplitude modulating clock signal.

[c16] 16.Thesoft-start charge pump circuit according to claim 15, wherein:
each of the at least one clock channel further includes:
an input stage inverter having a power supply terminal coupled to receive the supply voltage source for providing a constant amplitude clock signal to the output stage inverter.

[c17] 17. A method of activating a charge pump circuit, comprising steps of:
generating at least one clock signal whose amplitude gradually changes from an activation value during an amplitude modulation period, the amplitude modulation period lasting longer than a period of the at least one clock signal by one or more metric orders;
activating a charge pump by using the at least one clock signal with the amplitude of the activation value for converting a supply voltage source to a pumping voltage; and
operating the charge pump after the activation to gradually change an absolute value of the pumping voltage along with the change of the amplitude of the at least one clock signal, for suppressing a rising rate of the absolute value of the pumping voltage.

[c18] 18.Themethod according to claim 17, further comprising a step of:

modulating the amplitude of the at least one clock signal to reach a stable value after the amplitude modulation period.

[c19] 19.Themethod according to claim 18, wherein:
the stable value is equal to the supply voltage source.

[c20] 20. The method according to claim 17, wherein:
in the step of generating the at least one clock signal, the amplitude of the at least one clock signal is determined by a gradually increasing potential difference across a capacitor when the capacitor is charged.